The Aerocapacitor

A highly conductive, double-layer supercapacitor based on carbon aerogels

The aerocapacitor is an electrochemical, double-layer capacitor that uses thin-film carbon aerogel paper, developed at the Livermore Laboratory, as both the positive and negative electrodes. Livermore carbon aerogels are the ideal double-layer electrode material because they have high usable surface areas (>500 m^2/cm^3), controllable pore size and density (0.05–1.0 g/cm^3), and low electrical resistivity (<40 mΩÅcm).

The aerocapacitor is simple and inexpensive to produce with repeatable broad-process methods. It is environmentally benign (consisting of carbon and electrolytes) and is encased in standard plastic packaging.

Double-layer formation

In the aerocapacitor, two aerogel electrodes are separated by an electrically isolating, ionically conductive electrode separator that is flooded with a 5*M* KOH electrolyte. Each electrode is polarized with opposing charges when a charging voltage is applied. As voltage is applied, an electric double-layer forms at the solid–liquid interface. Because the aerogel and electrolyte are highly conductive, all of the potential drop in the device occurs across the carbon–electrolyte interface.

APPLICATIONS

- *Electric vehicles*
- *Load-leveling*
- *Memory backup*
- *Power supplies*
- *Preheaters for catalytic converters*

Aerogel microstructure delivers high conductivity

Because of its monolithic structure, Livermore's carbon aerogel demonstrates much higher conductivity than other forms of carbon and carbon powders. It is composed of covalently bonded carbon particles of approximately 120 Å. Raman analysis shows an in-plane microcrystallite size (La) of 25–30 Å, independent of particle size or bulk density. Electrical conduction takes place by the drift of the delocalized charge carriers within the carbon particles and by the transfer of carriers from one large conducting segment to another by hopping or tunneling. The activation energy for transport between carbon particles in the carbon aerogels is relatively small—in marked contrast to electrodes made from compacted carbon powders.

Packaged aerocapacitors with aqueous electrolytes, 5 V, 7.5 F.

High performance

The aeocapacitor has

- Capacities of up to 40 F/cm3
- Energy densities of 5 WÅh/kg with aqueous electrolytes
- Power densities of over 7 kW/kg
- Excellent low-temperature (–30°C) performance
- Low self-discharge (energy loss over days).

We added organic electrolytes to the aerocapacitor, demonstrating higher voltages and energies (3.0 V/cell, 10 WÅh/kg) with the reduced power caused by electrolyte resistance.

We are currently producing aerocapacitors in low-voltage, bipolar stacks wrapped in lightweight, polymer packaging. These devices have capacities of approximately 5 F at 5 V (see figure). Larger size and higher voltage devices are in development.

Availability: The aerocapacitor is available now. We are seeking industrial partners with whom we can develop commercial applications.

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